

Development of SMAP Freeze/Thaw algorithms using SMOS data over the Canadian Tundra.

P. Kalantari¹, M. Bernier¹, K.C. McDonald², and J. Poulin¹

1: INRS, Centre Eau Terre Environnement

2: CUNY Environmental Crossroads Initiative and CREST Institute

Centre - Eau Terre Environnement



Agence spatiale
canadienne Canadian Space
Agency



Centre
d'études
nordiques

INRS
Université d'avant-garde



Main Objective

Development of SMAP Freeze/Thaw algorithms using SMOS data over the Canadian Tundra.

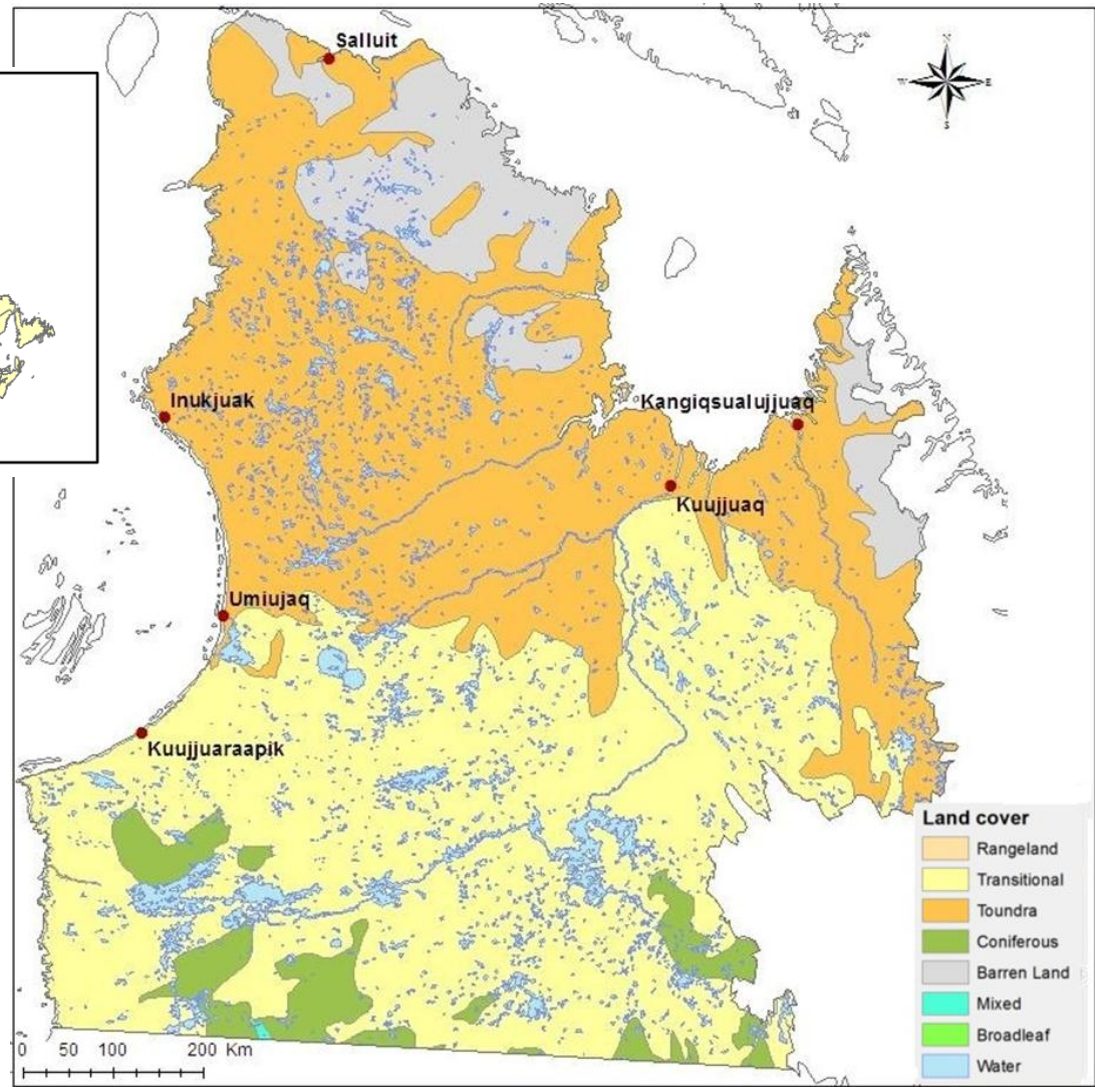
Specific objectives

- ❖ Develop and validate algorithms to monitor F/T over the Tundra region and the Boreal forest for the Future SMAP mission. Using SMOS and SAR L-Band Data or RADARSAT-2 data.
- ❖ Support and Enhance an Existing Ground Network in Northern Quebec as the Main Cal/Val Site related to F/T Products in Canada.

Experimental Site; NUNAVIK



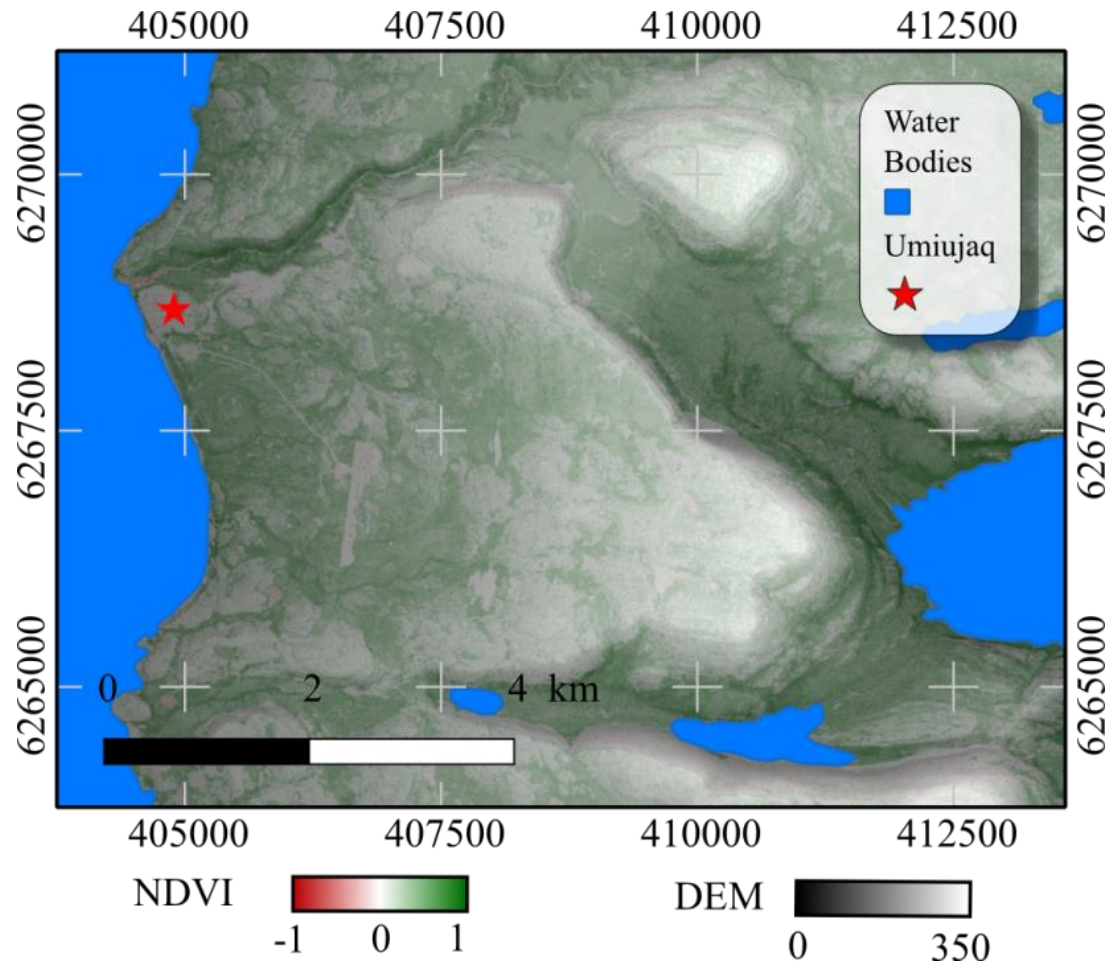
- ❖ Study area contains numerous lakes and large rivers.
- ❖ The water bodies decrease the Brightness Temperature of a given pixel



VALIDATION SITE; Umiujaq (near the Hudson Bay) Nunavik, Canada

Located at :

- ❖ 56.55° N, 76.55° O
- ❖ A zone of discontinuous permafrost
- ❖ At the northern Tree line limit
- ❖ Two distinct zones
 - 1) Coastal zone
 - 2) Valley Lac Guillaume-Deslile
- ❖ Research station of the Center for Northern Studies (CEN)

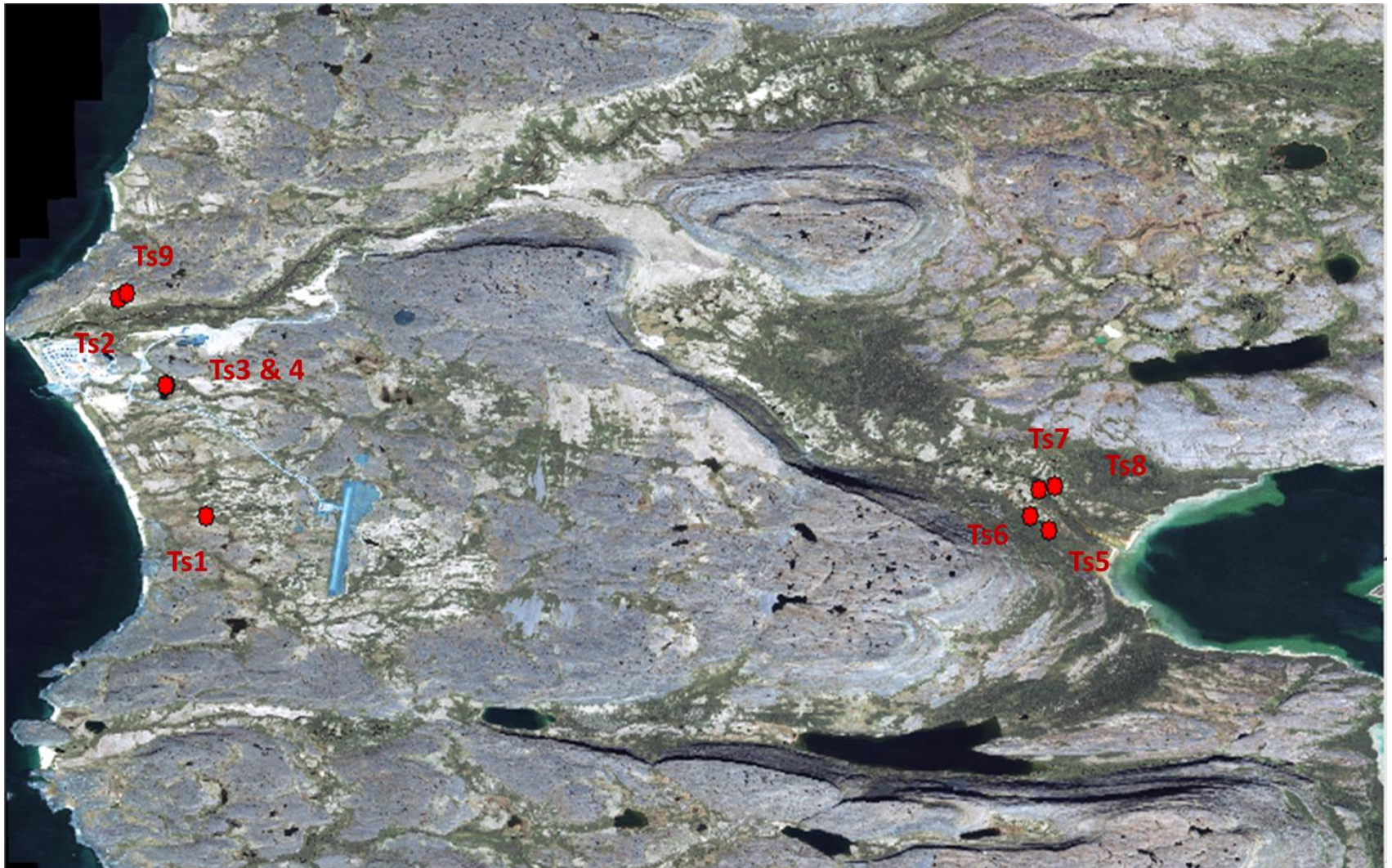








Location of Soil Temperature Sensors (Umiujaq)



Installed Soil Temperature Sensors



Sensor #5



Sensor #6

First Freezing Day, First thawing Day 2010-2011

2010-2011

# Sonde	Relief/Soil type	Vegetation type/ Height	First freezing day	First thawing day	Duration (day)
S1	Dune	0-1cm	11,19,2010	04,30,2011	163
S2	±Sandy	Lichen	01,25,2011	05,02,2011	98
S3	Sand	Shrubs	12,19,2010	05,06,2011	139
S4	Sand	Lichen	12,09,2010	05,06,2011	149
	Sand	Lichen	12,14,2010	05,06,2011	144
S5	Sand	Lichen	12,10,2010	05,01,2011	143
	Sand	Shrubs	12,09,2010	04,30,2011	143
	Humus	High shrubs	-	-	-
	Humus	Sand and shrubs	01,06,2011	05,02,2011	117
S6	Replat	60 cm	01,05,2011	05,01,2011	117
S7	Dune	55cm	12,14,2010	05,10,2011	148
S8	Slope	4 cm	12,14,2010	05,03,2011	141

First Freezing Day , First thawing Day 2011-2012

2011-2012

Sonde

Vegetation type/ Height

First freezing day

First thawing day

Duration (day)

S2

Lichen

01,23,2012

04,26,2012

95

S5

Lichen

11,26,2011

04,26,2012

153

S8

Horsetail lichen

11,26,2011

05,04,2012

161

S1

Shrubby/ sandy

11,28,2011

04,25,2012

150

S4

Lichen

11,26,2011

05,01,2012

158

S7

Lichen

11,19,2011

04,25,2012

159

S3

Shrubby

12,03,2011

05,01,2012

151

S6

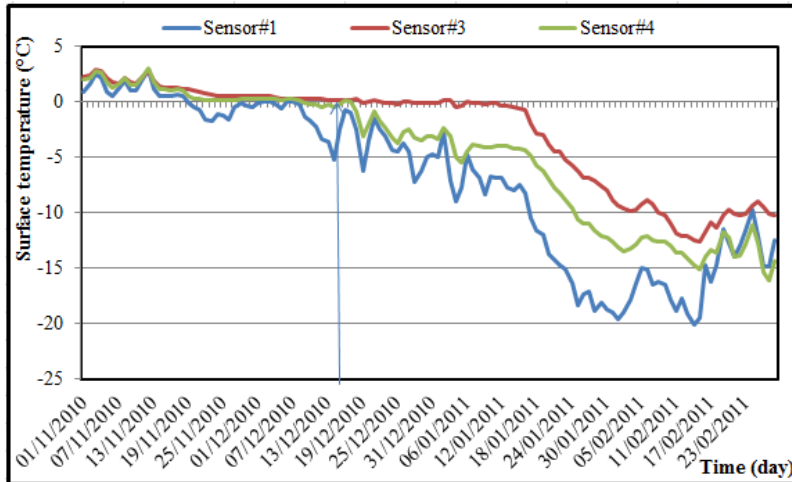
Shrubby

12,22,2011

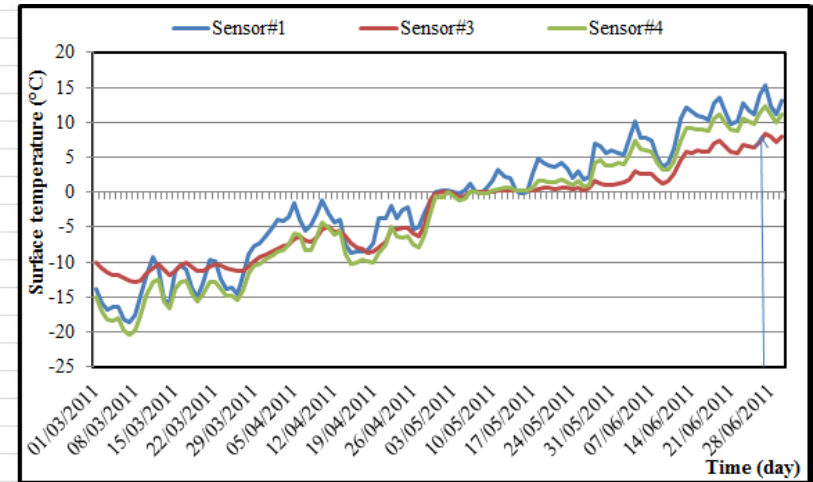
05,23,2012

154

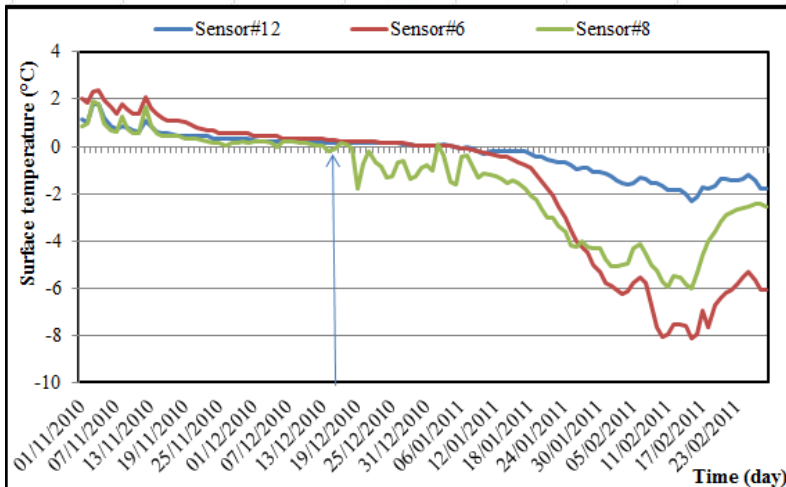
Soil Temperature (2010-2011)



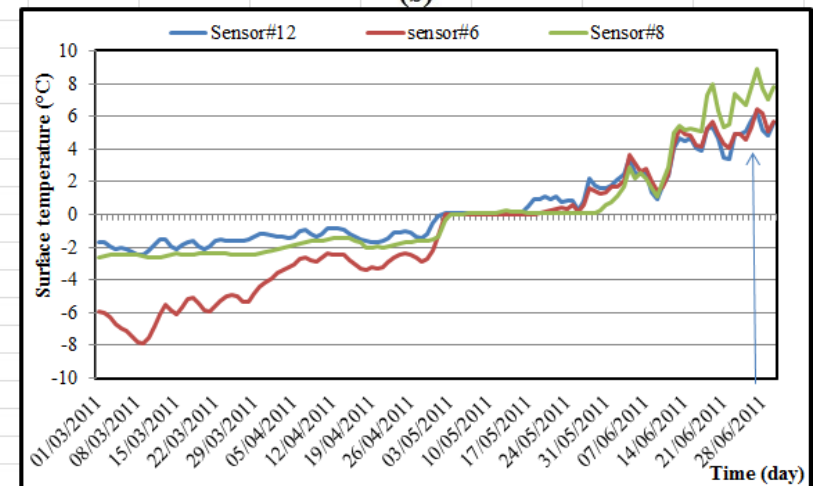
(a)



(b)

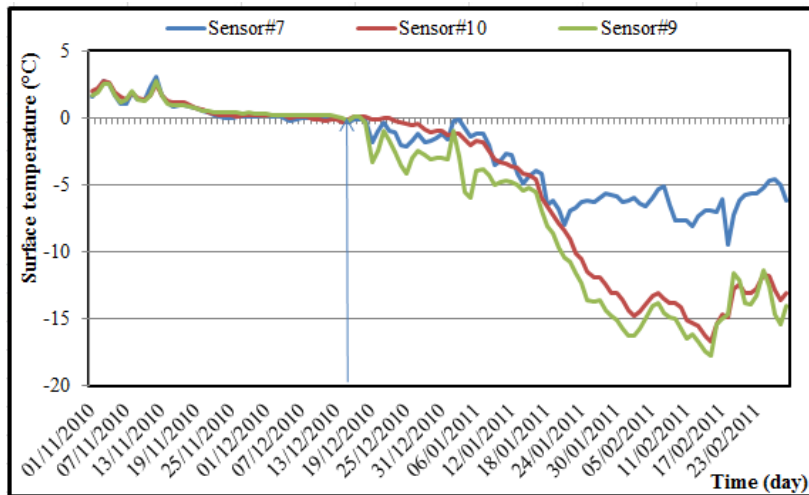


(c)

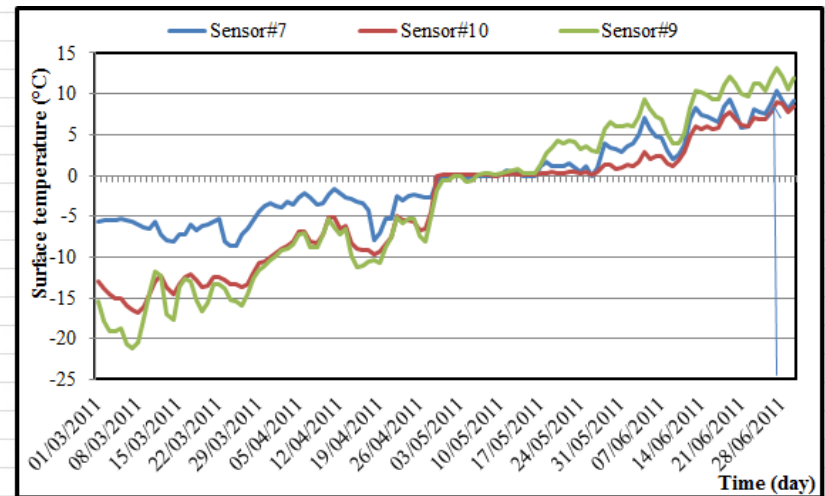


(d)

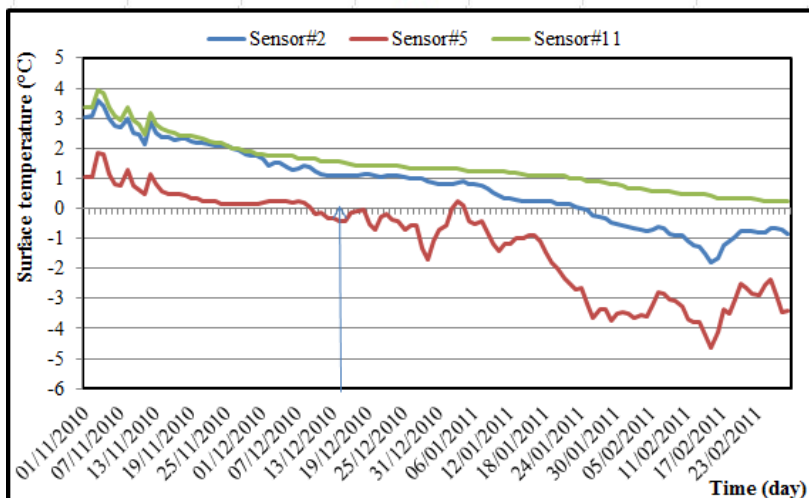
Soil Temperature (2010-2011)



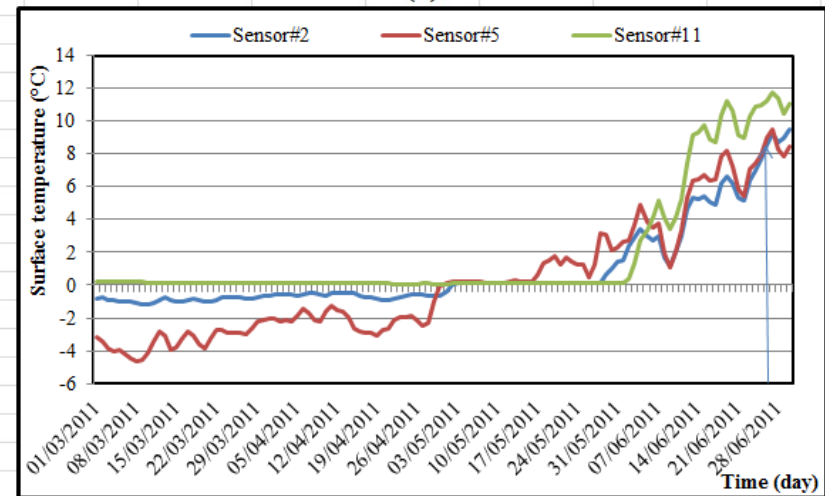
(a)



(b)



(c)



(d)

Frozen Soil Time Comperation (2010-2011) &(2011-2012)

# Sonde	S1	S2	S3	S4	S5	S6	S7	S8
First freezing day	11,19,2010	01,25,2011	12,19,2010	12,09,2010	12,10,2010	01,05,2011	12,14,2010	12,14,2010
	11,28,2011	01,23,2012	12,03,2011	11,26,2011	11,26,2011	12,22,2011	11,19,2011	11,26,2011
First thawing day	04,30,2011	05,02,2011	05,06,2011	05,06,2011	05,01,2011	05,01,2011	05,10,2011	05,03,2011
	04,25,2012	04,26,2012	05,01,2012	05,01,2012	04,26,2012	05,23,2012	04,25,2012	05,04,2012
Duration (day)	163	98	139	149	143	117	148	141
	150	95	151	158	153	154	159	161



Active Data; RADARSAT-2

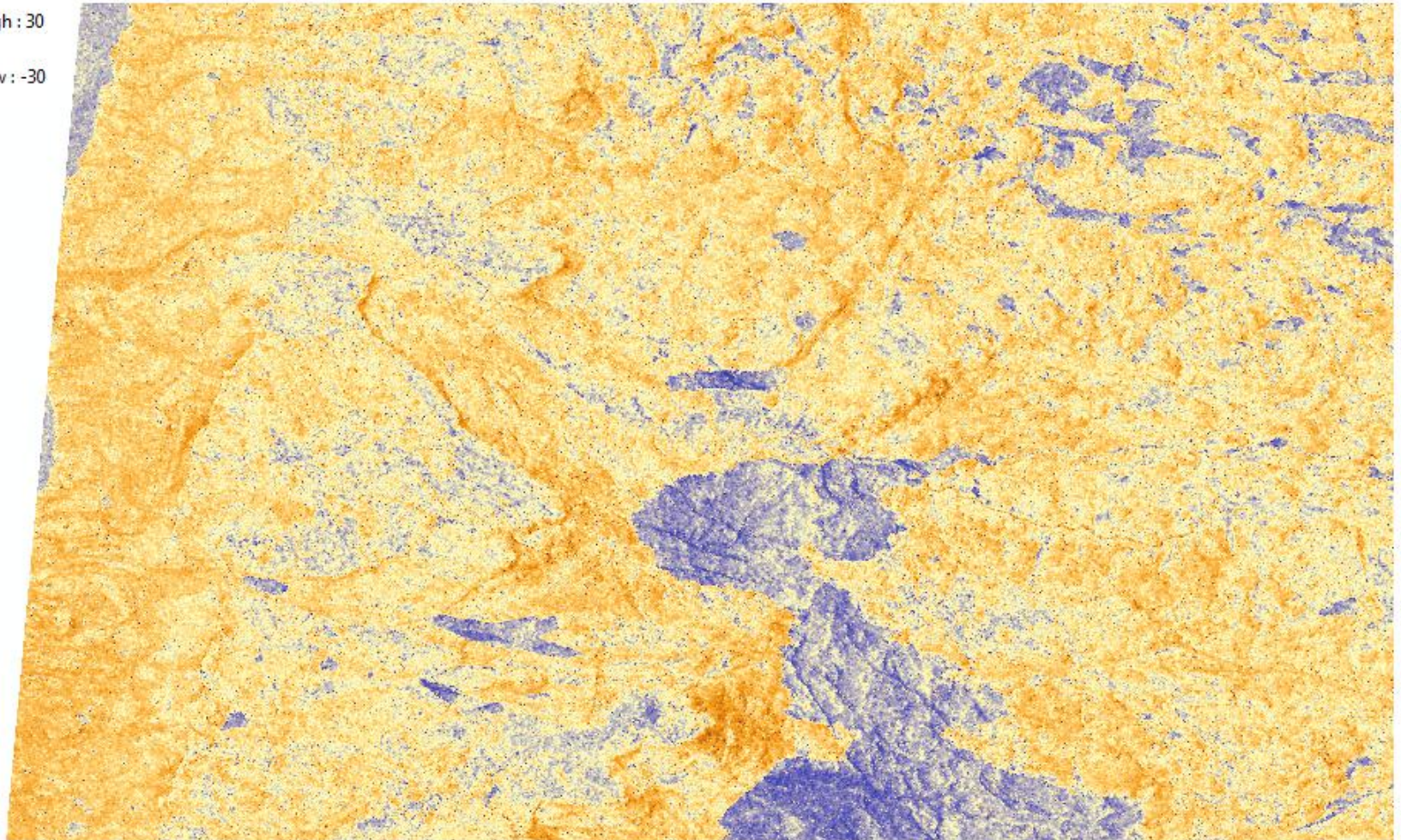
Scenes acquired from 2010 to 2012:

- ❖ 27 RADARSAT-2 Fine Quad-pol (HH, HV, VH, VV), $\approx 9\text{m}$ resolution.
- ❖ 2 incidence angles: 27° and 38°

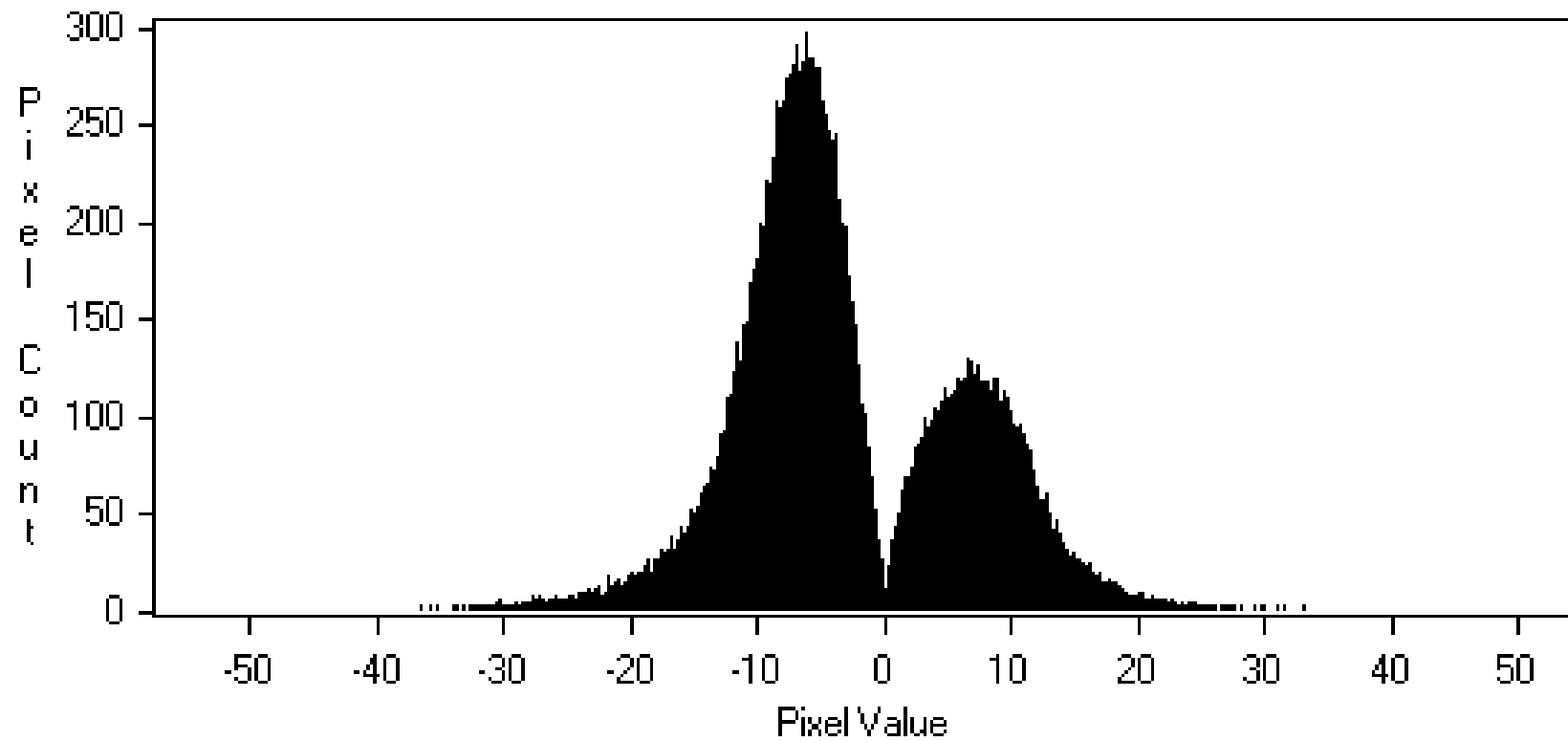
	Winter 2010	Spring 2010	Fall 2010	Winter 2011	Fall 2011	Winter 2012
RADARSAT-2	March , April	May	October, November	March, April	October, November, December	March, April
TerraSAR-X				March, April	November, December	March, April

Backscattering ratio, Dec 14, 2010 vs Jun 28, 2011

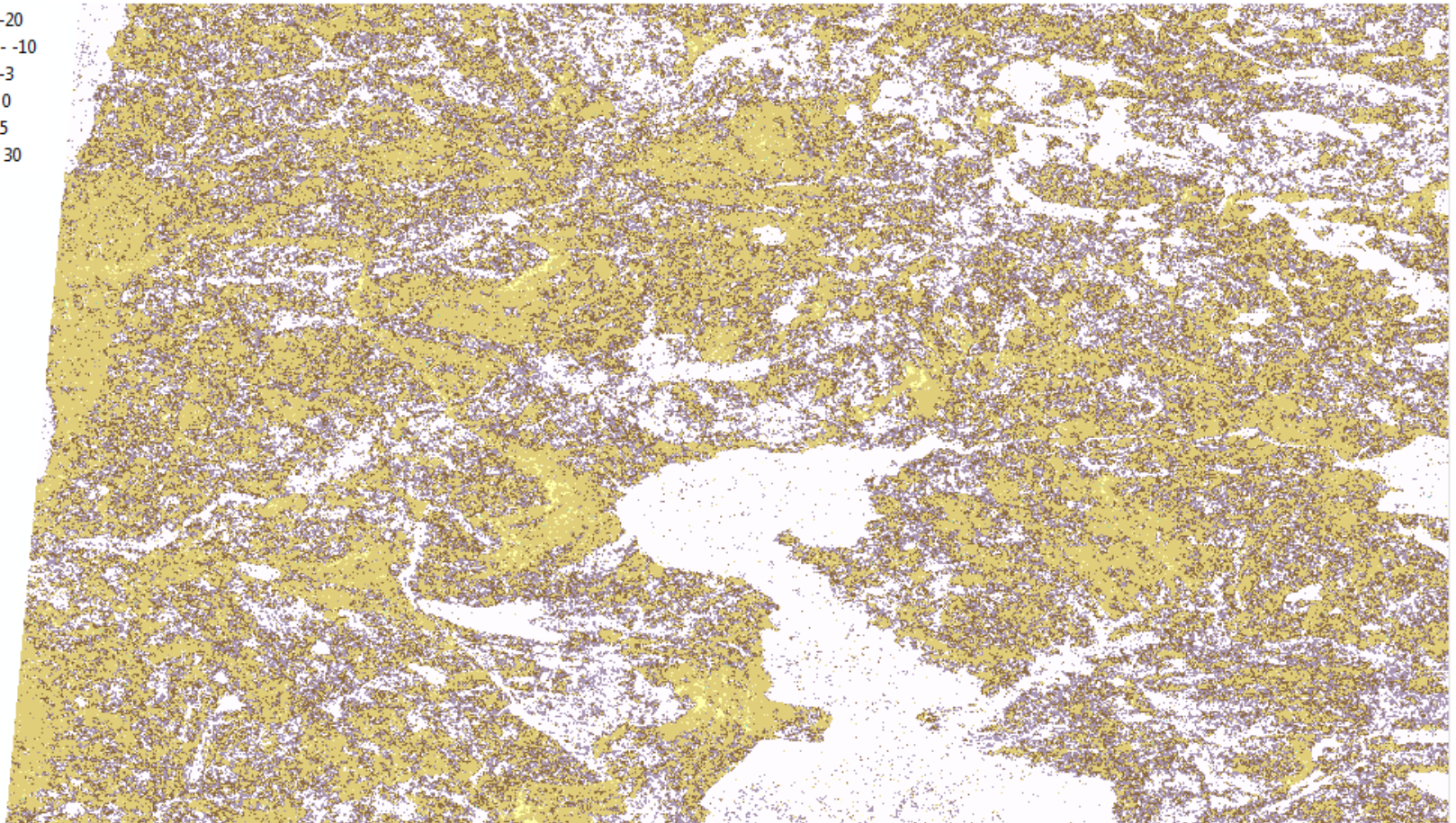
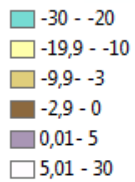
High : 30
Low : -30



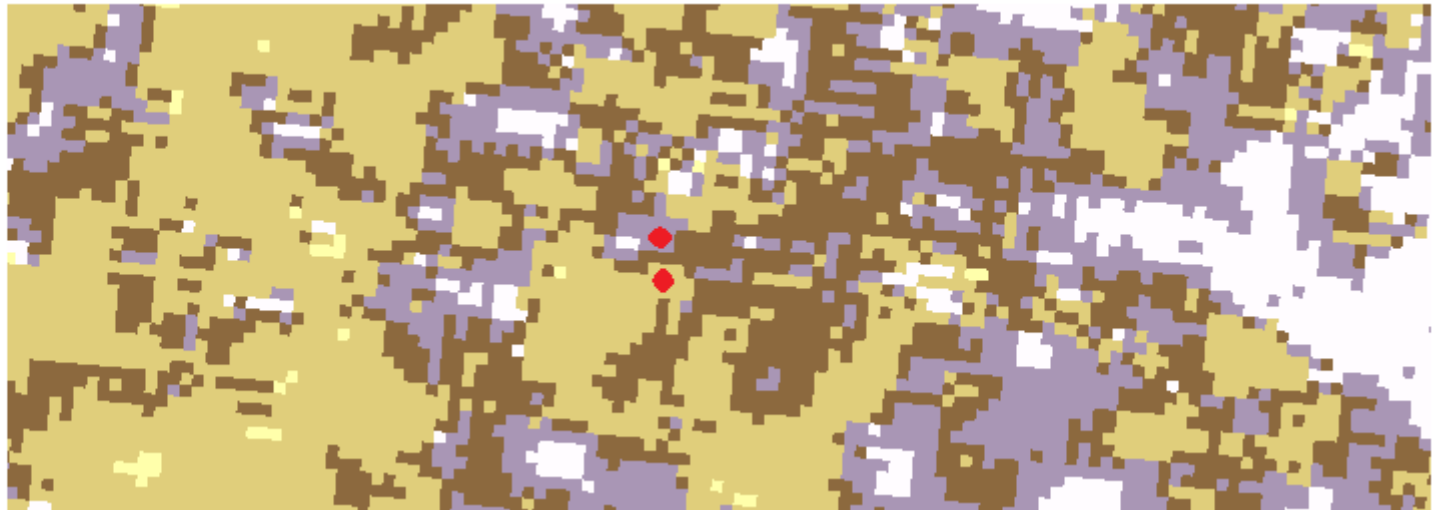
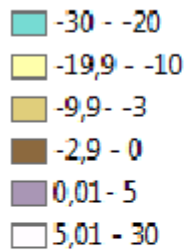
Backscattering ratio (14dec10-28jun11)



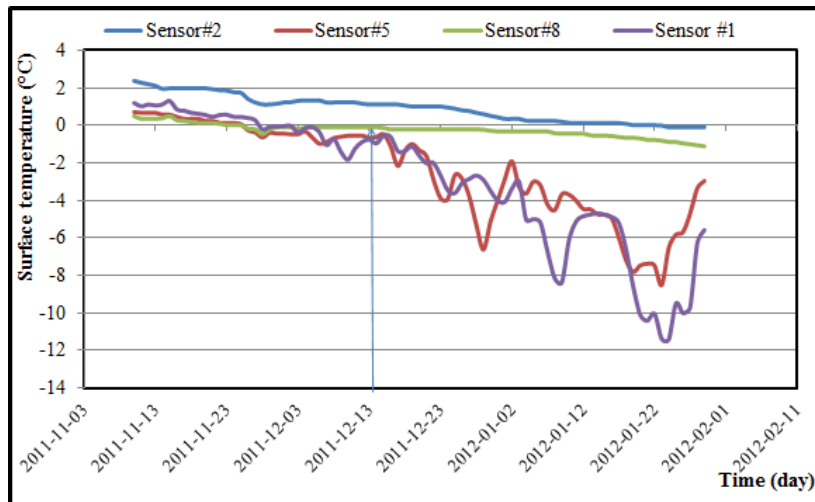
Backscattering ratio, Dec 03, 2011 vs Jun 28, 2011



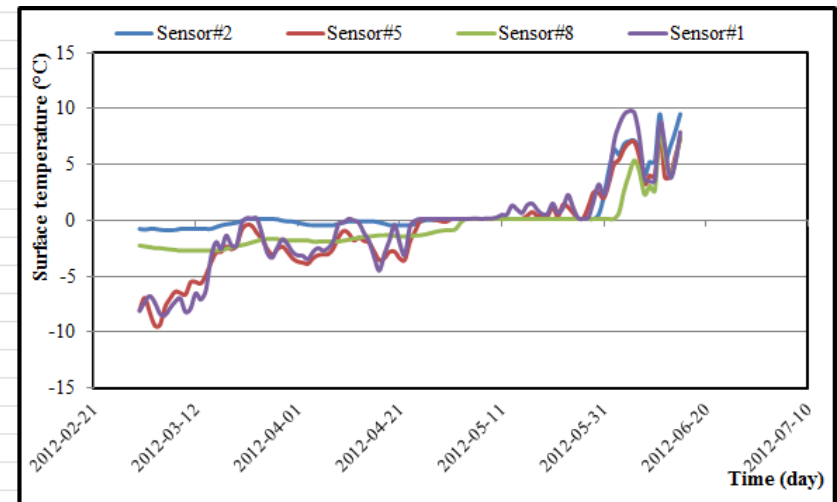
$[Cd^{2+}] = 10 \text{ nmol L}^{-1}$



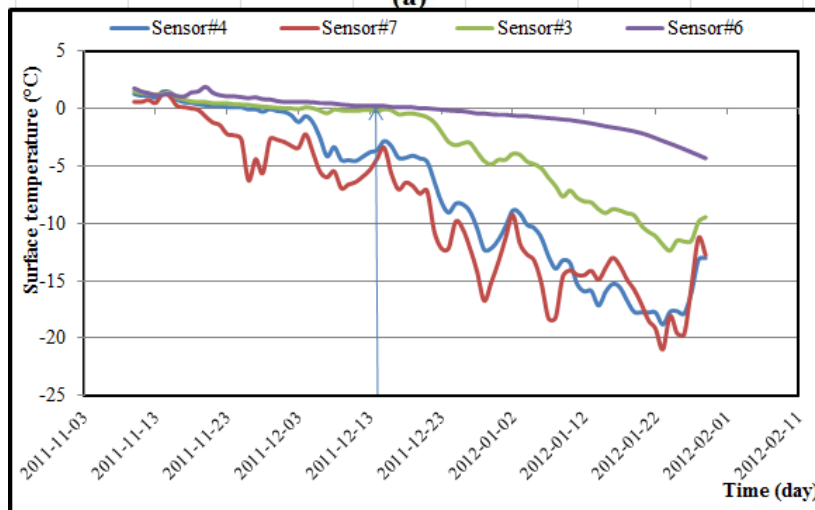
Soil Temperature (2011-2012)



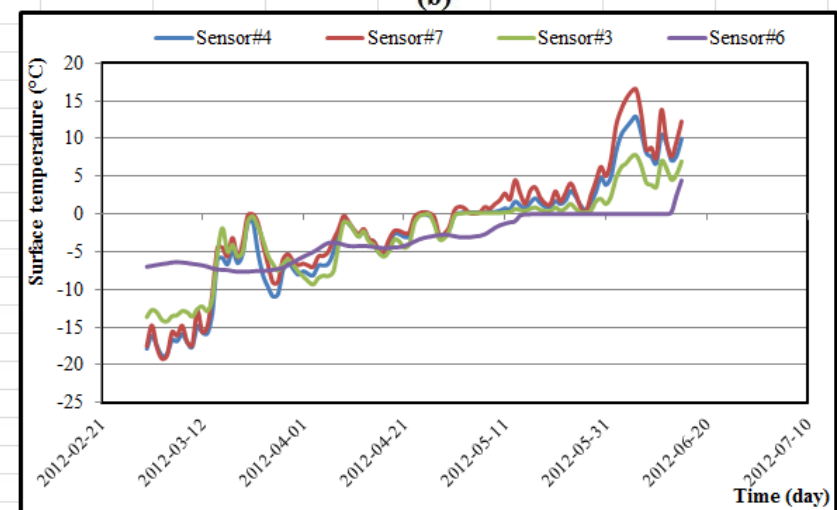
(a)



(b)



(c)



(d)

Conclusion

- ❖ Field data shows that freezing and thawing dates vary much spatially at the local scale in the tundra.
- ❖ Therefore, the field validation of the F/T state maps at the regional scale will be very important.
- ❖ RADARSAT-2 FT maps are a way to do it.
- ❖ The SMAP algorithms to be developed should be adapted to take care of the surface heterogeneity (vegetation, soil, relief).



Thank You for your Attention!
Question?